PATENT COOPERATION TREATY

9/787542

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

THALSØ-MADSEN, Birgit
Leo Pharmaceutical Products Ltd. A/S
Patent Department
Industriparken 55
DK-2750 Ballerup
DANEMARK

Date of mailing (day/month/year)
23 July 2002 (23.07.02)

Applicant's or agent's file reference
591

IMPORTANT NOTIFICATION

International application No.
PCT/DK01/00069

International filing date (day/month/year)
31 January 2001 (31.01.01)

1. The following indications appeared on record concerning:

[X] the applicant [X] the inventor [ ] the agent [ ] the common representative

Name and Address
PEDERSEN, Henrik
Dommervænget 26A, I.th
DK-4000 Roskilde
Denmark

State of Nationality: DK
State of Residence: DK
Telephone No.:
Facsimile No.:
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [ ] the name [X] the address [ ] the nationality [ ] the residence

Name and Address
PEDERSEN, Henrik
Herluf Trollesparken 33
DK-4340 Tølløse
Denmark

State of Nationality: DK
State of Residence: DK
Telephone No.:
Facsimile No.:
Teleprinter No.:

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

Authorized officer
Elisabeth KÖNIG (Fax 338 8970)
Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 591	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
International application No. PCT/DK 01/00069	International filing date (day/month/year) 31 January 2001	(Earliest) Priority Date (day/month/year) 31 January 2000
Applicant Leo Pharmaceutical Products Ltd.A/S et al		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readable form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

2. [X] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (See Box II).

4. With regard to the **title**,

   [ ] the text is approved as submitted by the applicant.

   [X] the text has been established by this Authority to read as follows:

   Use of Vitamin D-derivatives in the treatment of osteoporosis and related bone disorders, as well as novel Vitamin D3-derivatives.

5. With regard to the **abstract**,

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. -

   [ ] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK01/00069

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 15-16, 19-20
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

Claims 15-16, 19-20 relate to methods of treatment of the human or animal body by surgery or by therapy/ diagnostic methods practised on the human or animal body/Rule 39.1.(iv). Nevertheless, a search has been executed for these claims. The search has been based on the alleged effects of the compounds/compositions.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 01/00069

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: C07C 401/00, A61K 31/593, A61P 19/10
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: C07C, A61K, A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0567353 A1 (ALUMNI RESEARCH FOUNDATION), 27 October 1993 (27.10.93) --	1-20
A	WO 9115475 A1 (LEO PHARMACEUTICAL PRODUCTS), 17 October 1991 (17.10.91) -- --------	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 May 2001	- 3. 07. 01

Name and mailing address of the International Searching Authority
European Patent Office P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
Tel(+31-70)340-2040, Tx 31 651 epo nl,
Fax(+31-70)340-3016

Authorized officer

Anna Sjölund/BS
Telephone No.

SA 324854

INTERNATIONAL SEARCH REPORT

Information on patent family members

30/04/01

International application No.
PCT/DK 01/00069

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0567353 A1	27/10/93	IL 105474 D	00/00/00
		JP 3014241 B	28/02/00
		JP 6009405 A	18/01/94
		KR 156950 B	16/11/98
		KR 214194 B	02/08/99
		US 5393749 A	28/02/95
WO 9115475 A1	17/10/91	AT 114302 T	15/12/94
		AU 630804 B	05/11/92
		AU 7589291 A	30/10/91
		CA 2073983 A	01/10/91
		DE 69105267 D,T	27/04/95
		DK 522013 T	30/01/95
		EP 0522013 A,B	13/01/93
		ES 2066434 T	01/03/95
		GB 9007236 D	00/00/00
		GR 3015127 T	31/05/95
		IE 65283 B	18/10/95
		IE 910970 A	09/10/91
		KR 209179 B	15/07/99
		NZ 237607 A	26/05/93
		US 5374629 A	20/12/94

09/787548

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
P199801702 WO		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/DK00/00069	21/02/2000	19/02/1999
International Patent Classification (IPC) or national classification and IPC H01B12/08		
Applicant NKT RESEARCH CENTER A/S et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 5 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
13/09/2000	02.03.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Lohberger, S Telephone No. +49 89 2399 6723

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/DK00/00069

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
Description, pages:

1-3,5-9,12-14	as originally filed			
4,10,11,15,16	as received on	22/01/2001	with letter of	19/01/2001

Claims, No.:

1-19	as originally filed

Drawings, sheets:

1/3-3/3	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-19
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-19
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-19
	No:	Claims	

2. Citations and explanations
   see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
s e separate sheet

Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Reference is made to the following document/s/:

   D1: WO-A1-9639705
   D2: EP-A2-0623937
   D3: US-A-3730966

2. Claim 1 proposes a cable with three or more conducting layers, wherein the pitch angle of the conducting layers increases in steps from layer to layer from the radial innermost layer to an intermediate layer and then remains constant or decreases from the intermediate layer to the outermost conducting layer.

   This characterizing feature is neither known nor rendered obvious by the cited prior art:

   D1, especially description page 4, line 30 to page 6, line 24, page 20, line 19 to page 11, line 19, figures and claims discloses an AC cable as proposed in present claim 1 with the difference that D1 only proposes to gradually increase or decrease the pitch angle from layer to layer. An increase/decrease or constant feature fro the pitch angle is not mentioned in D1. The large pitch variations of D1 have the drawbacks as already mentioned in present Application on page 2.

   D2, especially description page 5, lines 5 to 9, figures 4 and 5 and claims discloses a high TC superconducting cable with several superconducting layers around a former and outer insulation. This cable however has no insulation between the conducting layers and therefore has a quite different construction

than the cable of claim 1. D2 therefore is not considered to be of relevance fro present Application.

D3, especially description column 2, line 20 to column 3, line 67 , figures and claims discloses a cable, wherein in the inner and outer structure the pitch angle of the different conducting layers must be the same. This is quite different to that what claim 1 intends (step by step increasing or decreasing values).

Consequently claim 1 is clearly novel under article 33(2) PCT.

Claim 1 formally seems to fulfil the requirements of article 33(3) PCT as well, since the prior art is silent about such special pitch angle arrangement within the different conducting layers. Such special arrangement seems to have the advantage of low AC-loss and less variations in winding pitch and so results in beneficial mechanical properties of the cable.

This last paragraph is only valid for claim 1 and not for present examples, since they do not show this pitch arrangement.

3. Independent claim 14 relates to a method for constructing a cable like proposed in claim 1 and therefore this claim is acceptable for the same reasons as already set out for claim 1. However here again the clarity objection in the light of the description must be raised.

4. Claims 2 to 13 and 15 to 18 are preferred embodiments of claims 1 or 14 and as such they fulfil the requirements of article 33(2) and (3) PCT as well.

5. The use of such an acceptable cable of claim 1 as proposed in claim 19 is acceptable as well under article 33(2) and (3) PCT for the same reasons as already set out for claim 1.

Re Item VIII

Certain observations on the international application

1. The examples of present Application (now page 10, line 21 to page 12, line 26) are out of the scope of claim 1. The examples do not show the feature wherein the pitch angle of the conducting layers increases in steps from layer to layer from the radial innermost layer to an intermediate layer and then remains constant or decreases from the intermediate layer to the outermost conducting layer.

   The Applicant's argumentation with regard to pitch length is not convincing. The examiner is well aware of the fact, that claim 1 relates to pitch angles and the examples relate to pitch length and that these features are inversely related to each other. However the calculation of the pitch angle according to Applicant's formula yields e.g. in the example on present page 10, lines 25 to 30 following pitch angles for layers 4 to 1:
   20,8°(layer 4), 21,5°, 23,5° and 25,4°(layer 1). These pitch angles are not in accordance with the requirements as set out in claim 1.

A preferred embodiment of the invention of claim 1 comprises the following features:

- at least one of said isolating layers has a thickness different from the thickness of at least one of the other isolating layers,
- at least one of said conducting layers has a thickness different from the thickness of at least one of the other conducting layers,
- at least one of said isolating layers includes material which is different from the material of at least one of the other isolating layers, or
- at least one of said conducting layers includes material, which is different from the material of at least one of the other conducting layers.

Hereby, a homogenous distribution of the current in the cable and thus a reduction of the AC losses in the cable is obtained. Even though a cable can be constructed having a single of the above-mentioned characteristics, two or more characteristics can be combined. Hereby, an increased degree of freedom when designing a cable of the above-mentioned type is obtained, as the desired homogenous distribution of the current in the cable can be obtained by varying one or more additional parameters, i.e. in addition to varying the winding pitches, the thickness of the isolating layers, the thickness of the conducting layers, the material of the isolating layers may be varied, and/or the material of the conducting layers may be varied. As a result, the variation in winding pitches can be reduced whereby further improvement of the mechanical properties of the cable is obtained.

In a preferred embodiment at least one of said isolating layers is thicker than the radial outermost of the neighbouring isolating layers. In another preferred

mutually separated by isolating layers 16 and 18 as shown in the figure. For example, the isolating layers include mylar, polyamide, polyester, paper, polyester imprinted paper or semiconductor material, and may also include magnetic material.

In the shown embodiment of a cable according to the invention, the isolating layers 16 and 18 varies in thickness, that is, the thickness of the isolating layers decrease in steps from layer to layer between a first value of the radial innermost isolating layer and a second value of the radial outermost isolating layer. By varying the thickness of the isolating layers of the conductor the inductance between the conducting layers is varied. By performing a suitable selection of the thickness of the individual isolating layers of the cable the current will distribute more equally between the conducting layers resulting in reduced AC losses. Below, examples of cables according to the invention are given.

An example shows a cable with four non-equidistant layers with almost equal winding pitches. The radius given is the radius on which a superconducting tape of 0.18 mm thickness has to be wound.

Layer	1	2	3	4
Radius/mm	18.9	18.65	18.2	17.5
Pitch/mm	250	270	290	290

It is noted that the resulting cable has an almost homogeneous current distribution in the three outermost layers.

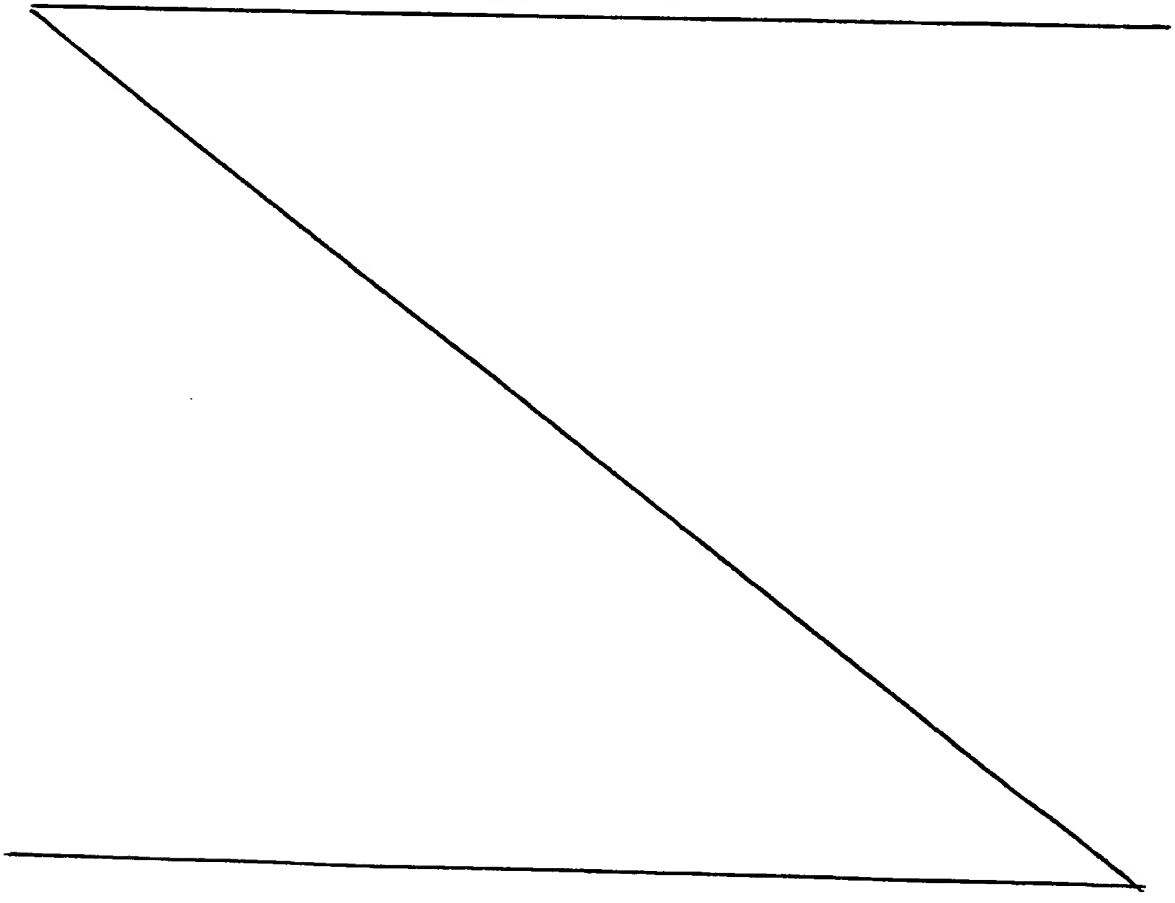
It is further noted that the pitches are rather small and almost equal which improves the mechanical (bending)

properties of the cable. Differential contraction of different layers is minimised.

One example of a winding pattern in a superconducting cable that approximately fulfils the inductance equation is shown below. In this case, the first winding (layer 8) is made into a diameter of 32 mm.

Layer	1	2	3	4	5	6	7	8
Pitch/mm	205	240	290	350	400	440	480	470

Mylar type with a thickness of 50 µm is used as layer insulation, and the superconducting tapes are about 0.2 mm thick. It is noted, that here is a specific pattern in the winding pitches - the outer layers have short winding pitches, and the inner layer have longer pitches, becoming constant for layers 7 and 8.



In this embodiment both the thickness of the isolating layers and the material of the isolating layers varies from layer to layer. As can be seen from the figure, the thickness of the isolating layers 26, 27 and 28 decrease in steps from layer to layer between a first value of the radial innermost isolating layer 26 and a second value of the radial outermost isolating layer 28. As mentioned, the material of the isolating layers can also vary from layer to layer, and may include magnetic materials.

It should be noted that the central former of a cable according to the invention can be formed of any isolating material, conventional conducting material, or superconducting material depending on the intended use of the cable. The described principle of a cable having varying thickness of the individual isolating layers can also be used on cables without a central former.

Further, it should be noted that a cable according to the invention can include an arbitrary number of conducting layers. Likewise, the thickness of the isolating and conducting layers and the pitches can be varied arbitrarily.

In another embodiment of the invention one or more of the isolating layers consists of a number of layers. Hereby, such isolating layers - which may be called multi-layered isolating layers - can be composed of different materials giving the isolating layer desired mechanical and/or electrical characteristics.

It is further noted, that the desired reduction of the AC losses can be reached as a combination of the effect obtained by the variation of the thickness of the isolating layers and/or the isolating material. In

addition, pitches of the conducting layers may also be varied.

Although preferred embodiments of the present invention have been described and shown, the invention is not restricted to those. It may also be embodied in other ways within the subject-matter defined in the following claims. For example, the same principle can be used in multi-core cables, i.e. a cable of the described type can be a single core of a multi-core cable having one or more of similar cores and/or one or more of state of the art cable cores. A cable core may also include a number of sub-cores which may or may not have the structure of a core according to the invention. As another example, the cable can include one or more non-concentric conducting and/or isolating layers. Further, one or more of the conducting and/or isolating layers can be formed to have an arbitrary shape, e.g. oval or approximately oval, elliptical or approximately elliptical.

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* 591

Box No. I TITLE OF INVENTION

THERAPEUTIC USE OF VITAMIN D ANALOGUES

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

Leo Pharmaceutical Products Ltd. A/S
(Løvens kemiske Fabrik Produktions-
aktieselskab)
Industriparken 55
DK-2750 Ballerup
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☐ This person is also inventor.

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Teleprinter No.

State *(that is, country)* of nationality: DK

State *(that is, country)* of residence: DK

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

GRUE-SØRENSEN, Gunnar
Thyrasvej 3
DK-4000 Roskilde
Denmark

This person is:
☐ applicant only
☒ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: DK

State *(that is, country)* of residence: DK

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

THALSØ-MADSEN, Birgit
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+45 44 92 38 00

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+45 44 66 00 12

Teleprinter No.

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

PEDERSEN, Henrik
Dommervænget 26A, 1.th
DK-4000 Roskilde
Denmark

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: DK

State *(that is, country)* of residence: DK

This person is applicant for the purposes of:
- ☐ all designated States
- ☐ all designated States except the United States of America
- ☒ the United States of America only
- ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

BINDERUP, Ernst Torndal
Ludvig Hegners Allé 8A
DK-2630 Taastrup
Denmark

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: DK

State *(that is, country)* of residence: DK

This person is applicant for the purposes of:
- ☐ all designated States
- ☐ all designated States except the United States of America
- ☒ the United States of America only
- ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

TRANHOLM, Mikael
Dronningensvej 28
DK-2000 Frederiksberg
Denmark

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: DK

State *(that is, country)* of residence: DK

This person is applicant for the purposes of:
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- ☐ all designated States except the United States of America
- ☒ the United States of America only
- ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

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- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of:
- ☐ all designated States
- ☐ all designated States except the United States of America
- ☐ the United States of America only
- ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

☒ **AP** **ARIPO Patent:** **GH** Ghana, **GM** Gambia, **KE** Kenya, **LS** Lesotho, **MW** Malawi, **MZ** Mozambique, **SD** Sudan, **SL** Sierra Leone, **SZ** Swaziland, **TZ** United Republic of Tanzania, **UG** Uganda, **ZW** Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT

☒ **EA** **Eurasian Patent:** **AM** Armenia, **AZ** Azerbaijan, **BY** Belarus, **KG** Kyrgyzstan, **KZ** Kazakhstan, **MD** Republic of Moldova, **RU** Russian Federation, **TJ** Tajikistan, **TM** Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☒ **EP** **European Patent:** **AT** Austria, **BE** Belgium, **CH and LI** Switzerland and Liechtenstein, **CY** Cyprus, **DE** Germany, **DK** Denmark, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **IE** Ireland, **IT** Italy, **LU** Luxembourg, **MC** Monaco, **NL** Netherlands, **PT** Portugal, **SE** Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☒ **OA** **OAPI Patent:** **BF** Burkina Faso, **BJ** Benin, **CF** Central African Republic, **CG** Congo, **CI** Côte d'Ivoire, **CM** Cameroon, **GA** Gabon, **GN** Guinea, **GW** Guinea-Bissau, **ML** Mali, **MR** Mauritania, **NE** Niger, **SN** Senegal, **TD** Chad, **TG** Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

☒ **AE** United Arab Emirates
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☒ **DE** Germany .....
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☒ **ZA** South Africa .....
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Check-box reserved for designating States which have become party to the PCT after issuance of this sheet:

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Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)*

Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1) 31 January 2000 (31/01/00)	60/179,426	US		
item (2)				
item (3)				

☐ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s):

** Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used)*: ISA / EP

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority)*: Date *(day/month/year)* Number Country *(or regional Office)*

Box No. VIII CHECK LIST; LANGUAGE OF FILING

This international application contains the following **number of sheets**:

request	:	4
description (excluding sequence listing part)	:	36
claims	:	6
abstract	:	1
drawings	:	2
sequence listing part of description	:	
Total number of sheets	:	49

This international application is **accompanied** by the item(s) marked below:

1. ☒ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☒ priority document(s) identified in Box No. VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☒ other *(specify)*: cheque

Figure of the drawings which should accompany the abstract:

Language of filing of the international application: English

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

Leo Pharmaceutical Products Ltd. A/S
(Løvens kemiske Fabrik Produktions-aktieselskab)

Birgit Thalsø-Madsen

Gunnar Grue-Sørensen

Henrik Pedersen

Ernst Torndal Binderup

Mikael Tranholm

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1. Date of actual receipt of the purported international application:	2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4. Date of timely receipt of the required corrections under PCT Article 11(2):	
5. International Searching Authority (if two or more are competent): ISA /	6. ☐ Transmittal of search copy delayed until search fee is paid.

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Date of receipt of the record copy by the International Bureau:

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 01/00069

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: C07C 401/00, A61K 31/593, A61P 19/10
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: C07C, A61K, A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0567353 A1 (ALUMNI RESEARCH FOUNDATION), 27 October 1993 (27.10.93) --	1-20
A	WO 9115475 A1 (LEO PHARMACEUTICAL PRODUCTS), 17 October 1991 (17.10.91) -- --------	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 May 2001	- 3. 07. 01
Name and mailing address of the International Searching Authority European Patent Office P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel(+31-70)340-2040, Tx 31 651 epo nl, Fax(+31-70)340-3016	Authorized officer Anna Sjölund/BS Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK01/00069

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 15-16, 19-20
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK01/00069

Claims 15-16, 19-20 relate to methods of treatment of the human or animal body by surgery or by therapy/ diagnostic methods practised on the human or animal body/Rule 39.1.(iv). Nevertheless, a search has been executed for these claims. The search has been based on the alleged effects of the compounds/compositions.

INTERNATIONAL SEARCH REPORT

Information on patent family members

30/04/01

International application No.
PCT/DK 01/00069

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0567353 A1	27/10/93	IL 105474 D	00/00/00
		JP 3014241 B	28/02/00
		JP 6009405 A	18/01/94
		KR 156950 B	16/11/98
		KR 214194 B	02/08/99
		US 5393749 A	28/02/95
WO 9115475 A1	17/10/91	AT 114302 T	15/12/94
		AU 630804 B	05/11/92
		AU 7589291 A	30/10/91
		CA 2073983 A	01/10/91
		DE 69105267 D,T	27/04/95
		DK 522013 T	30/01/95
		EP 0522013 A,B	13/01/93
		ES 2066434 T	01/03/95
		GB 9007236 D	00/00/00
		GR 3015127 T	31/05/95
		IE 65283 B	18/10/95
		IE 910970 A	09/10/91
		KR 209179 B	15/07/99
		NZ 237607 A	26/05/93
		US 5374629 A	20/12/94

9/890624

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : H01B 12/08, 7/30, 7/02 — A1

(11) International Publication Number: WO 00/49626

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(21) International Application Number: PCT/DK00/00069

(22) International Filing Date: 21 February 2000 (21.02.00)

(30) Priority Data:
PA 1999 00221 19 February 1999 (19.02.99) DK

(71) Applicant *(for all designated States except US)*: NKT RESEARCH CENTER A/S [DK/DK]; Priorparken 878, DK–2605 Brøndby (DK).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: DÄUMLING, Manfred [DE/DK]; Nykæ 54, 7 th, DK–2605 Brøndby (DK).

(74) Agent: HOFMAN–BANG A/S; Hans Bekkevolds Allé 7, DK–2900 Hellerup (DK).

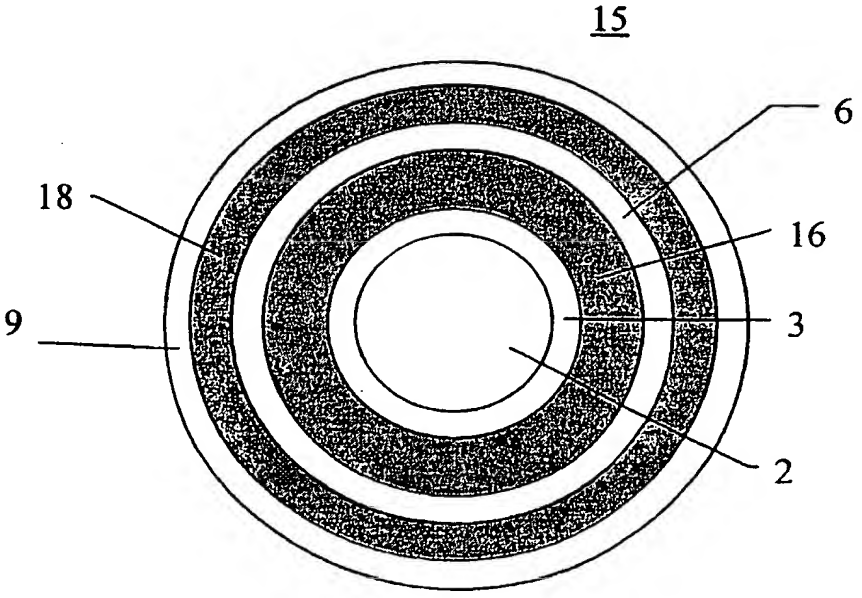
(81) Designated States: AE, AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), DM, EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: A CABLE, A METHOD OF CONSTRUCTING A CABLE, AND USE OF A CABLE

(57) Abstract

The invention relates to a cable and to a method of constructing a cable with at least one cable core having three or more conducting layers which are mutually separated by isolating layers, resistive layers, or reduced electrical contact surfaces. The conducting layers include electrical conductors, which are arranged helically with predetermined pitch angles. According to the invention, the predefined pitch angles increase in steps from layer to layer from the radial innermost conducting layer to an intermediate conducting layer located between the radial innermost conducting layer, and said predefined pitch angles remain substantially constant or decrease in steps from layer to layer from said intermediate conducting layer to the radial outermost conducting layer. As a result, an even current distribution and hereby a reduced AC loss is obtained. The invention further relates to the use of an AC cable according to the invention as a power cable.



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EE	Estonia	**LR**	Liberia	**SG**	Singapore		

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 00/00069

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01B 12/08, H01B 7/30, H01B 7/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

QUESTEL: EDOC, WPIL, JAPIO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9639705 A1 (SIEMENS AKTIENGESELLSCHAFT), 12 December 1996 (12.12.96), page 4, line 30 - page 6, line 24; page 10, line 19 - page 11, line 19, figures 1,4	1-19
A	EP 0623937 A2 (SUMITOMO ELECTRIC INDUSTRIES, LTD.), 9 November 1994 (09.11.94), page 5, line 5 - line 9, figures 4,5	1-19
A	US 3730966 A (MARCEL AUPOIX ET AL), 1 May 1973 (01.05.73), column 2, line 20 - column 3, line 67, figure 1	1-19

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 May 2000	24 -05- 2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Bengt Christensson/MP Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

02/12/99

International application No.
PCT/DK 00/00069

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9639705 A1	12/12/96	DE 19520589 A	12/12/96
		DE 19680401 D	00/00/00
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		CH 550498 A	14/06/74
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		JP 56051445 B	05/12/81
		NL 7200845 A	25/07/72

A cable, a method of constructing a cable, and use of a cable

The present invention relates to a cable with at least one cable core having three or more conducting layers which are mutually separated by isolating layers, where said conducting layers include electrical conductors which are arranged helically with predetermined pitch angles, and in particular to an electrical cable with reduced AC loss.

When using electrical power cables it is generally desirable to obtain as low power loss as possible. Cables adapted to have low losses are known from the prior art. The prior art discloses AC cables with at least one cable core having a number of conducting layers, which are mutually separated by isolating layers. The conducting layers are normally formed by electrical conductors, which are arranged helically with predetermined pitch angles.

The innermost conductor which may be of superconducting material is normally wound spirally around a central former and hereby forms a conducting layer. Likewise, the other conducting layers which may also be of superconducting material are normally wound spirally around the isolating layers adapted to separate the conducting layers. The number of conducting layers required depends on the desired use of the cable and on the current carrying capability of the tapes used.

The current distribution between the layers depends on the winding pitches, the layer radii, the layer thickness, and the resistivity of the layers of the conductors, as the inductance between the layers depends

on the winding pitches. According to the prior art pitches are therefore varied from layer to layer in a given way. As a result the current will distribute more equally between the conducting layers resulting in reduced AC losses.

WO 96/39705 discloses a cable with a central carrier body around which electrical conductors are arranged helically with predetermined pitch angles in at least three conductor positions. The pitch angles of the conductors in the individual conductor positions are selected such that they either increase or decrease in steps from position to position between a first value of the radial innermost conductor position and a second value of the radial outermost conductor position.

Even though the AC cables according to the prior art are found to be useful, they have the drawback that quite large variations of the winding pitches are required in order to obtain an equal current distribution. Furthermore, in practice, it is difficult to produce cables with these large variations in pitches.

The object of the invention is to provide an AC cable with low AC-loss and which overcome the disadvantages of the state of the art cables.

This object is achieved by a cable with at least one cable core having three or more conducting layers which are mutually separated by isolating layers, where said conducting layers include electrical conductors which are arranged helically with predetermined pitch angles, in which said predefined pitch angles increase in steps from layer to layer from the radial innermost conducting layer to an intermediate conducting layer located between the radial innermost conducting layer and the radial

outermost conducting layer, and said predefined pitch angles remain substantially constant or decrease in steps from layer to layer from said intermediate conducting layer to the radial outermost conducting layer.

Hereby, a homogenous distribution of the current in the cable and thus a reduction of the AC losses in the cable is obtained. Further, a cable having less variations of the winding pitches compared to cables of the prior art can be obtained. This is of interest as strongly varying pitches lead to differential thermal contraction of the different layers during cool-down of the cable. Further, small variation of the pitches between the layers is desirable as these result in beneficial mechanical properties of the cable.

The invention is based on the fact that the equations to be solved in order to design a cable of the above-mentioned type having reduced AC losses have been found to be very complex and cannot be solved analytically. The equations include a plurality of coupled parameters making the system difficult to solve, i.e. when varying one parameter, one or more other parameters may also be affected. When using a simplified model, the relation between some parameters can be explained e.g. the inductance is found to decrease as the radius of a conducting layer is increased, and the self-inductance of a conducting layer increases as the pitch angle increases. In cables not containing superconductors, layer resistance also plays a role. In practice it has been found that a homogenous current distribution can be obtained over the cross section of a cable of the above-mentioned type when designing the cable according to the invention, and hereby the above-mentioned advantages are obtained.

The object of the invention can also be achieved by a cable in which:

- at least one of said isolating layers has a thickness different from the thickness of at least one of the other isolating layers,
- at least one of said conducting layers has a thickness different from the thickness of at least one of the other conducting layers,
- at least one of said isolating layers includes material which is different from the material of at least one of the other isolating layers, or
- at least one of said conducting layers includes material, which is different from the material of at least one of the other conducting layers.

Hereby, a homogenous distribution of the current in the cable and thus a reduction of the AC losses in the cable is obtained. Even though a cable can be constructed having a single of the above-mentioned characteristics, two or more characteristics can be combined. Hereby, an increased degree of freedom when designing a cable of the above-mentioned type is obtained, as the desired homogenous distribution of the current in the cable can be obtained by varying one or more additional parameters, i.e. in addition to varying the winding pitches, the thickness of the isolating layers, the thickness of the conducting layers, the material of the isolating layers may be varied, and/or the material of the conducting layers may be varied. As a result, the variation in winding pitches can be reduced whereby further improvement of the mechanical properties of the cable is obtained.

In a preferred embodiment at least one of said isolating layers is thicker than the radial outermost of the neighbouring isolating layers. In another preferred

embodiment at least one of said conducting layers is thicker than the radial outermost of the neighbouring conducting layers.

In accordance with a further embodiment said thickness of said isolating layers and/or said conducting layers decrease in steps from layer to layer between a first value of the radial innermost isolating layer and a second value of the radial outermost isolating layer.

In a preferred embodiment, the resistivity of the conducting layer material increases in steps from layer to layer from a first value of the radial innermost conducting layer to a second value of the radial outermost conducting layer, i.e. the invention can be used in non-superconducting cables.

In another preferred embodiment that said conductors includes super-conducting material, i.e. the invention can be used in superconducting cables. For example, said super-conducting material is high-T_c super-conducting material.

The invention also relates to a method of producing a cable of the above-mentioned type.

The present invention further relates to the use of a cable according to the invention as a power cable.

The present invention will now be described more fully with reference to the drawings, in which

Figure 1 shows a schematic cross section view of the current carrying part of a cable according to the prior art,

Figure 2 illustrates a first embodiment of the current carrying part of a cable according to the invention,

Figure 3 illustrates a second embodiment of the current carrying part of a cable according to the invention,

Figure 4 illustrates a third embodiment of the current carrying part of a cable according to the invention, and

Figure 5 illustrates the winding pitch and the pitch angle of a conductor in a conducting layer of an electrical cable.

Generally, it is desirable to obtain as low power loss as possible in electrical cables, e.g. when the cable is used as an AC power cable, e.g. an underground cable, or an overhead power line, e.g. as power lines for electrically driving vehicles such as trains.

The prior art discloses cables with at least one cable core having a number of conducting layers which are mutually separated by isolating layers, resistive layers, or reduced electrical contact surfaces. The term isolating layer shall be read as isolating layers, resistive layers, or reduced electrical contact surfaces in this context. The conducting layers are normally formed by electrical conductors which are arranged helically with predetermined pitch angles.

Figure 1 is a cross section view of a cable 1 according to the prior art and illustrates the structure of the cable 1. The cable 1 includes a central former 2 around which an electrical conductor is arranged helically with a predetermined pitch angle. The conductor hereby forms a conducting layer 3 which is adapted to carry an electrical current in the cable 1.

As can be seen from the figure, the shown cable 1 includes four conducting layers 3, 6, 9 and 12. The conducting layers are mutually separated by so-called isolating layers 5, 8 and 11, i.e. conducting layers 3 and 6 are separated by the isolating layer 5, conducting layer 6 and 9 are separated by the isolating layer 8, and so forth. The isolating layers have a given constant or an approximately constant thickness.

The other conducting layers 6, 9 and 12 also include conductors which are wound spirally around the isolating layers adapted to separate the conducting layer. The number of conducting layers in the cable depends on the desired use of the cable and on the current carrying capability of the tapes used.

The winding pitch and the pitch angle of a conductor in a cable is illustrated in Figure 5. The figure shows a cable 501 including a number of layers which is illustrated by the view to the left in the figure. To the right, the same cable 501 is shown. A conductor 502, which is wound around a given layer in the cable, is also shown in the figure. The conductor 502 illustrates a conductor in a conducting layer of the cable 501. In the figure WP shows the winding pitch of the conductor, i.e. the distance from the start to the end of a single winding, and the pitch angle.

The current distribution between the layers depends on the variation of the winding pitches of the conductors as the inductance between the layers depends on the winding pitches. According to the prior art the pitches are therefore varied from layer to layer in the following. The pitch angles of the conductors in the conducting layers 3, 6, and 9 and 12 all have a given different

value which is selected such that they either increase or decrease in steps from layer to layer between a first value of the radial innermost conducting layer, i.e. conducting layer 3, and a second value of the radial outermost conducting layer, i.e. conducting layer 9. As a result the current will distribute more equally between the individual conducting layers resulting in reduced AC losses compared to the losses in a similar known cable having an equal or approximately equal pitch in all layers.

According to the invention the layer radii and/or the materials of the isolating layers or conductive layers is selected in to fulfil (at least approximately) the following inductance equation:

$$V_i = M_{ij}\frac{dI_i}{dt} + R_i I_i \quad \text{for} \quad \frac{I_i}{A_i} = \frac{I_j}{A_j} \text{ and } V_i = V_j$$

Where M_{ij} is an inductance matrix, and V_i and I_i are the layer voltage and current, and A_i is the layer cross sectional area. By definition all the V_i are identical (the layers are in parallel). As indicated it is desirable to achieve a cable in which I_i/A_i are also identical. In practice, this is achieved by varying the winding pitches of the conducting layers and/or the layer radii and/or the materials of the isolating layers. Some examples are given below.

It is noted that the high AC loss of the cables having approximately equal pitch in all layers is due to the fact that the current concentrates in the outer layers of the cable. This leads to losses that are virtually identical to the ones found in a solid tube conductor of the dimensions of the cable.

The drawback of cables according to the prior art is the quite large variations of winding pitches which are required to obtain a desired equalization of the current distribution. Cables having these large pitch variations are often technically unrealisable. In addition, strongly varying pitches may not be desirable as they lead to differential thermal contraction of the different layers during cool-down or warm-up of the cable. Further, small variation of the pitches between the layers as well as small pitches are desirable as these result in beneficial mechanical properties of the cable.

According to the invention, the pitch angles of the electrical conductors in the conducting layers are varied in the following way. The value of the pitch angles increases in steps from layer to layer between a first value in the radial innermost conducting layer to a second value in an intermediate conducting layer. The intermediate conducting layer is a conducting layer located between the radial innermost of the conducting layers and the radial outermost of the conducting layers. Furthermore, the value of the pitch angles decreases or remains substantially constant from layer to layer between the second value in the intermediate conducting layer and a third value in the outermost of the conducting layers. The variation in pitch angles are not illustrated in a separate figure, but when referring to figure 1, the innermost conducting layer and the outermost conducting layer are denoted 3 and 12, respectively. The intermediate layer may be the conducting layer 6 or the conducting layer 9.

Figure 2 illustrates another embodiment of a cable according to the invention. The figure is a cross section view of a cable 15 having a central former 2 and three conducting layers 3, 6 and 9. The conducting layers are

mutually separated by isolating layers 16 and 18 as shown in the figure. For example, the isolating layers include mylar, polyamide, polyester, paper, polyester imprinted paper or semiconductor material, and may also include magnetic material.

In the shown embodiment of a cable according to the invention, the isolating layers 16 and 18 varies in thickness, that is, the thickness of the isolating layers decrease in steps from layer to layer between a first value of the radial innermost isolating layer and a second value of the radial outermost isolating layer. By varying the thickness of the isolating layers of the conductor the inductance between the conducting layers are varied. By performing a suitable selection of the thickness of the individual isolating layers of the cable the current will distribute more equally between the conducting layers resulting in reduced AC losses. Below, two examples of cables according to the invention are given.

In a first example the cable consists of 8 conducting layers. The central former has an outer diameter of 35 mm, and the thickness for the superconducting tape with insulation is 0.23 mm. In the shown example, Bi2223 is used as superconducting material and mylar is used as the isolating material. The winding pitches are as follows. It is noted that negative pitches denote opposite winding directions of the conductor.

Layer	1	2	3	4	5	6	7	8
Radius/mm	19,23	19,00	18,77	18,54	18,19	17,96	17,73	17,50
Pitch/mm	150	215	340	740	-900	-335	-220	-180

The thickness of the four innermost layers is constant and of the four outermost layers is constant. However,

there has to be a gap of 0.12 mm between layers 4 and 5 in order to achieve equal currents in each layer and thus lowest losses at the critical current.

A second example shows a cable with four non-equidistant layers with almost equal winding pitches. The radius given is the radius on which a superconducting tape of 0.18 mm thickness has to be wound.

Layer	1	2	3	4
Radius/mm	18.9	18.65	18.2	17.5
Pitch/mm	250	270	290	290

It is noted that the resulting cable has an almost homogeneous current distribution in the three outermost layers.

It is further noted that the pitches are rather small and almost equal which improves the mechanical (bending) properties of the cable. Differential contraction of different layers is minimised.

One example of a winding pattern in a superconducting cable that approximately fulfils the inductance equation is shown below. In this case, the first winding (layer 8) is made into a diameter of 32 mm.

Layer	1	2	3	4	5	6	7	8
Pitch/mm	205	240	290	350	400	440	480	470

Mylar type with a thickness of 50 μm is used as layer insulation, and the superconducting tapes are about 0.2 mm thick. It is noted, that here is a specific pattern in the winding pitches - the outer layers have short winding pitches, and the inner layer have longer pitches, becoming constant for layers 7 and 8.

Another example is shown below for a four layer cable with a central body. The central body is made from aluminium, and the layers consist of tightly wound copper tapes with for example Mylar inter-layer insulation of 0.05 mm thickness.

Layer	1	2	3	4	5
Material	Cu	Cu	Cu	Cu	Al
Outer diameter/mm	51.0	43.9	36.8	29.6	21,8
Pitch/mm	180	300	700	700	∞

The same kind of trend in the winding pattern is visible as in the superconducting cable - the outer layers have short winding pitches, i.e. large pitch angles, and the inner layers have longer winding pitches, i.e. shorter pitch angles. It is noted that in this cable the layer thickness of the conducting layer decrease from the inside to the outside. Another example of a copper cable is given below. In this case the outer diameter of the cable is 51 mm, and the body diameter is 21.8 mm - just like in the above-mentioned example. The conductor layer thickness is approximately constant. It is noted that the symbol "∞" in the table indicates that the given conducting layer is solid.

Layer	1	2	3	4	5	6	7	8
Material	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu
Pitch/mm	150	190	250	400	500	600	600	∞

Again, the pattern of the winding pitches follows the same trends as seen before - short pitches on the outside, and long pitches on the inside layers. The values of the pitches have been adjusted to account for the dimensions and the resistive component in the

inductance equation, which is again approximately fulfilled.

A further improvement of the mechanical properties (torsional strength) of the cable can be achieved when the conductors of at least one of said conducting layers have reverse winding direction in respect to the conductors of at least one of the neighbouring conducting layers.

As was seen above the variation of thickness of the isolating layers can be combined by a variation of pitch angle of the conducting layers, a well as a variation of the thickness of the conducting layers and/or their material.

It is noted that the conductors may include high-T_c superconducting materials, e.g. Y-Ba-Cu-O or (Bi,Pb)-Sr-Ca-Cu-O. The conductors may also include low-T_c superconducting materials, e.g. Nb-based superconducting materials. Or, the conductors may be conventional conductors. It is further noted that the conductor may be formed as tapes, e.g. multi-filament superconducting tapes.

Figure 3 illustrates a further embodiment of a cable according to the invention. The figure shows a cross section view of a cable 20 which include a central former 2 and four conducting layers 3, 6, 9 and 12. The conducting layers are mutually separated by a first isolating layer 21, a second isolating layer 22, and a third isolating layer 23; see Figure 3.

In the shown embodiment the isolating layers all have the same thickness, but in contrast to the prior art cable shown in figure 1, the material of the isolating layers

can vary from layer to layer, i.e. the first, second and third isolation layers 21, 22, 24 consist of a first, second and third isolating material, respectively. Magnetic materials may be included in some, but not all layers.

According to the invention the materials of the isolating layers are selected in accordance with their magnetical properties. As mentioned previously, a plurality of effects have influence on the current distribution in the cable, and according to the invention the magnetical properties of the isolating layers have been found to be one of these. The magnetical susceptibility of the isolating layer separating two conducting layers effects the mutual inductance between the conducting layers. The influence of the magnetical properties of the isolating layers can be explained using a simplified model. In general, the mutual inductance decreases as the magnetically susceptibility increases. Therefore, the current distribution between the conducting layers of a cable can be adjusted by selecting the materials of the isolating layers properly, i.e. an even current distribution and hereby a reduced AC loss can be obtained. In one embodiment, the magnetical susceptibility of the isolating layers vary in steps from layer to layer, e.g. from a first value of the innermost isolating layer to a second value - higher than the first value - of the outermost isolating layer.

Figure 4 illustrates a further embodiment of a cable according to the invention. The figure shows a cross section view of a cable 25 which include a central former 2 and four conducting layers 3, 6, 9 and 12. The conducting layers are mutually separated by a first, second and third isolating layer 26, 27 and 28; see Figure 4.

In this embodiment both the thickness of the isolating layers and the material of the isolating layers varies from layer to layer. As can be seen from the figure, the thickness of the isolating layers 26, 27 and 28 decrease in steps from layer to layer between a first value of the radial innermost isolating layer 26 and a second value of the radial outermost isolating layer 28. As mentioned, the material of the isolating layers can also vary from layer to layer, and may include magnetic materials.

It should be noted that the central former of a cable according to the invention can be formed of any isolating material, conventional conducting material, or superconducting material depending on the intended use of the cable. The described principle of a cable having varying thickness of the individual isolating layers can also be used on cables without a central former.

Further, it should be noted that a cable according to invention can include an arbitrary number of conducting layers. Likewise, the thickness of the isolating and conducting layers and the pitches can be varied arbitrarily.

In another embodiment of the invention one or more of the isolating layers consists of a number of layers. Hereby, such isolating layers - which may be called multi-layered isolating layers - can be composed of different materials giving the isolating layer a desired mechanical and/or electrical characteristics.

It is further noted, that the desired reduction of the AC losses can be reached as a combination of the effect obtained by the variation of the thickness of the isolating layers and/or the isolating material. In

addition, pitches of the conducting layers may also be varied.

Although preferred embodiments of the present invention have been described and shown, the invention is not restricted to those. It may also be embodied in other ways within the subject-matter defined in the following claims. For example, the same principle can be used in multi-core cables, i.e. a cable of the described type can be a single core of a multi-core cable having one or more of similar cores and/or one or more of state of the art cable cores. A cable core may also include a number of sub-cores which may or may not have structure of a core according to the invention. As an other example, the cable can include one or more non-concentric conducting and/or isolating layers. Further, one or more of the conducting and/or isolating layers can be formed to have an arbitrary shape, e.g. oval or approximately oval, elliptical or approximately elliptical.

Patent Claims:

1. A cable with at least one cable core having three or more conducting layers which are mutually separated by isolating layers, where said conducting layers include electrical conductors which are arranged helically with predetermined pitch angles, characterized in that said predefined pitch angles increase in steps from layer to layer from the radial innermost conducting layer to an intermediate conducting layer located between the radial innermost conducting layer and the radial outermost conducting layer, and said predefined pitch angles remain substantially constant or decrease in steps from layer to layer from said intermediate conducting layer to the radial outermost conducting layer.

2. A cable according to claim 1, characterized in that a least one of said isolating layers has a thickness different from the thickness of at least one of the other isolating layers.

3. A cable according to claim 1 or 2, characterized in that at least one of said conducting layers has a thickness different from the thickness of at least one of the other conducting layers.

4. A cable according to one or more of claims 1-3, characterized in that at least one of said isolating layers is thicker than the radial outermost of the neighbouring isolating layers.

5. A cable according to one or more of claims 1-4, characterized in that at least one of said conducting layers is thicker than the radial outermost of the neighbouring conducting layers.

6. A cable according to one or more of claims 1-5, c h a r a c t e r i z e d in that said thickness of said isolating layers decrease in steps from layer to layer between a first value of the radial innermost isolating layer and a second value of the radial outermost isolating layer.

7. A cable according to one or more of claims 1-6, c h a r a c t e r i z e d in that said thickness of said conducting layers decrease in steps from layer to layer between a first value of the radial innermost conducting layer and a second value of the radial outermost conducting layer.

8. A cable according to one or more of claims 1-7, c h a r a c t e r i z e d in that at least one of said isolating layers includes material which is different from the material of at least one of the other isolating layers.

9. A cable according to claim 8, c h a r a c t e r i z e d in that the magnetical susceptibility of the isolating layers varies from layer to layer.

10. A cable according to one or more of the preceding claims, c h a r a c t e r i z e d in that at least one of said conducting layers includes material which is different from the material of at least one of the other conducting layers.

11. A cable according to claim 10, c h a r a c - t e r i z e d in that the resistivity of the conducting layer material increases in steps from layer to layer from a first value of the radial innermost

counducting layer to a second value of the radial outermost conducting layer.

12. A cable according to one or more of claims 1-10, characterized in that said conductors includes super-conducting material.

13. A cable according to claim 12, characterized in that said super-conducting material is high-T_c super-conducting material.

14. A method of constructing a cable with at least one cable core having three or more conducting layers which are mutually separated by isolating layers, where said conducting layers include electrical conductors which are arranged helically with predetermined pitch angles characterized in that said predefined pitch angles are selected to increase in steps from layer to layer from the radial innermost conducting layer to an intermediate conducting layer located between the radial innermost conduction layer and the radial outermost conduction layer, and said predefined pitch angles are selected to remain substantially constant or decrease in steps from layer to layer from said intermediate conducting layer to said radial outermost conducting layer.

15. A method according to claim 14, characterized in that the thickness of at least one of said isolating layers is selected to be different from the thickness of at least one of the other isolating layers.

16. A method according to claim 14 or 15, characterized in that the thickness of at least one of said conducting layers is selected to be

different from the thickness of at least one of the other conducting layers.

17. A method according to one or more of claims 14-16, characterized in that the material of at least one of said isolating layers is selected to be different from the material of at least one of the other isolating layers.

18. A method according to one or more of claims 14-17, characterized in that the material of at least one of said conducting layers is selected to be different from the material of at least one of the other conducting layers.

19. Use of cable according to any one of the preceding claims as an AC power cable, an overhead line, or a drive cable for an electrically driving vehicle.

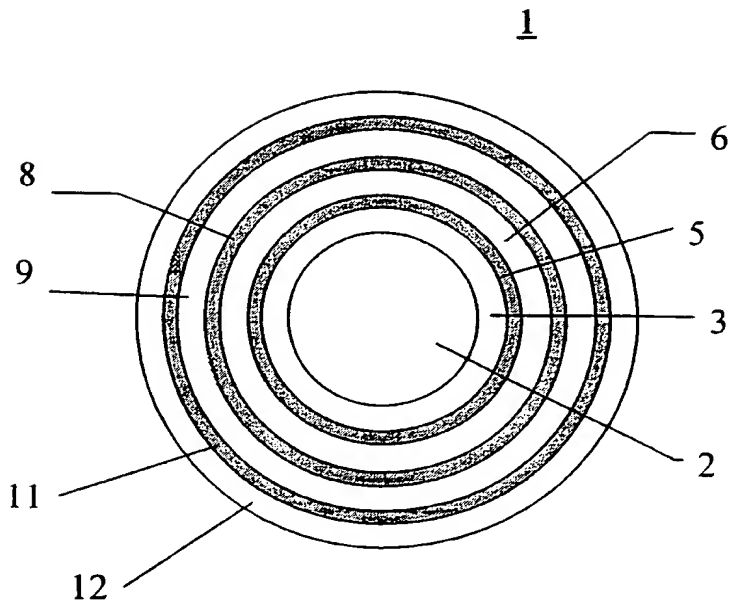

FIG. 1

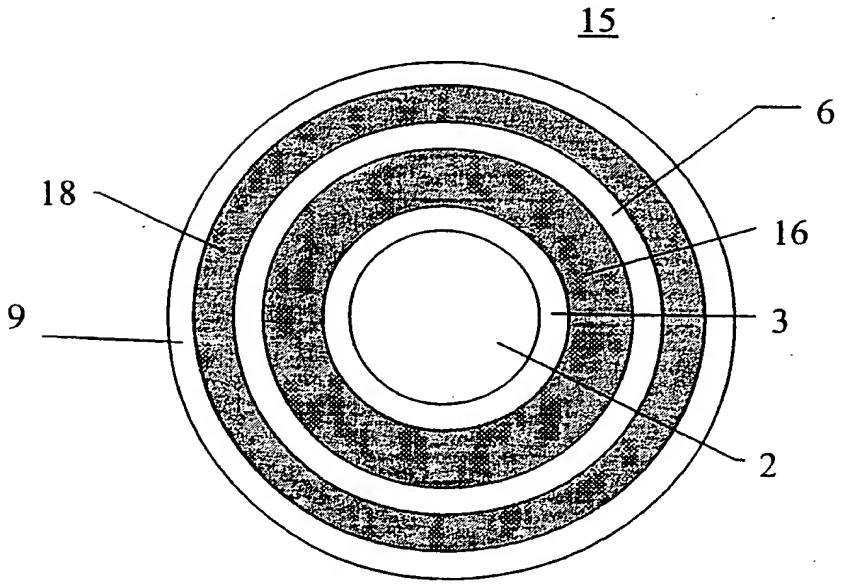

FIG. 2

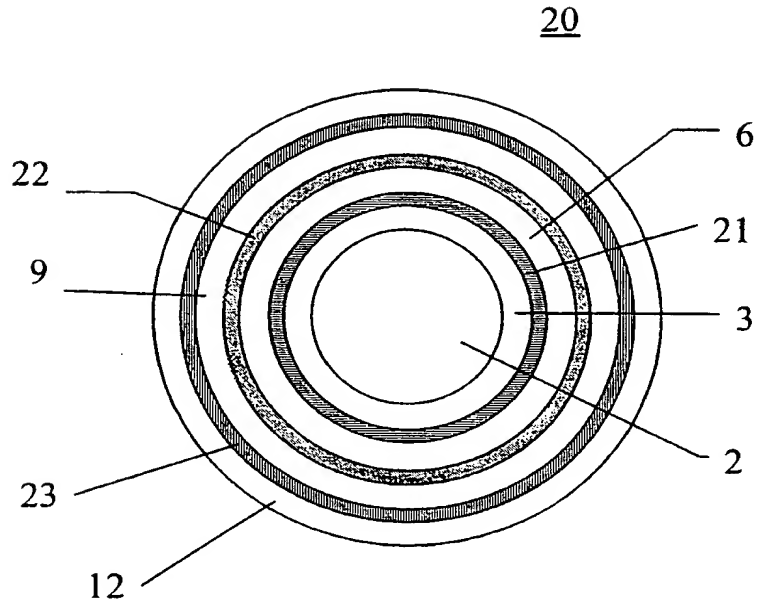

FIG. 3

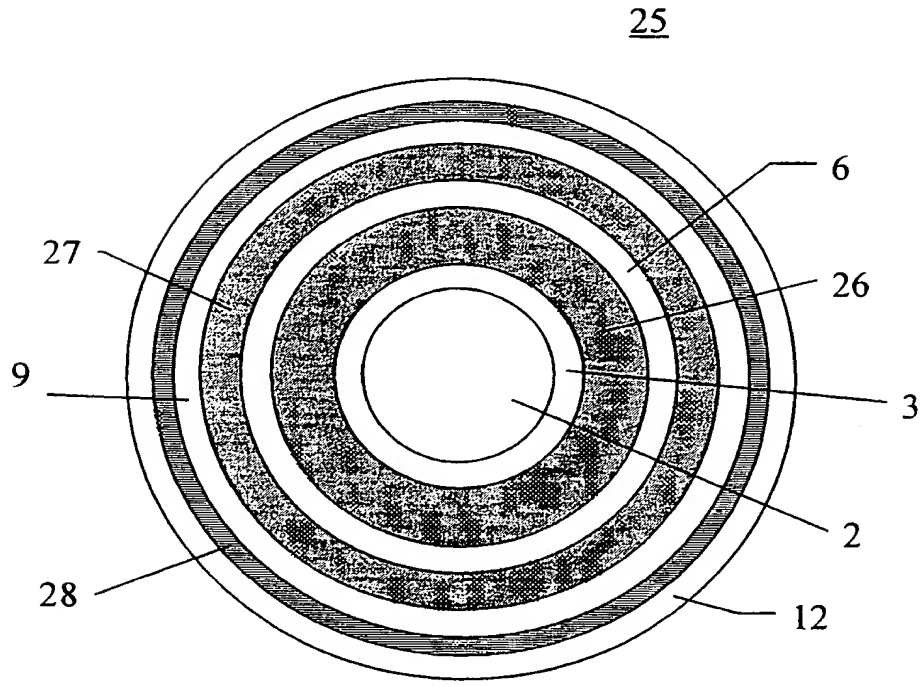

FIG. 4

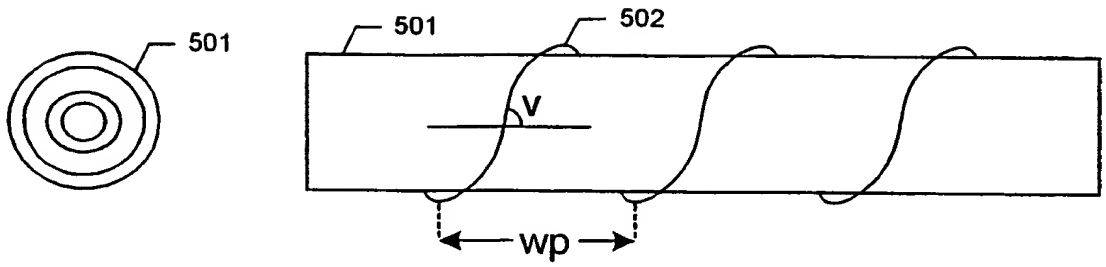

FIG. 5

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. DK 9100091 SA 46249

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 21/08/91
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A- 0078704	11-05-83	CA-A- 1204752	20-05-86
		GB-A,B 2114570	24-08-83
		JP-A- 2000163	05-01-90
		JP-B- 2024268	29-05-90
		JP-A- 58126861	28-07-83
		US-A- 4772433	20-09-88
		CA-A- 1221707	12-05-87
		DE-A- 3278400	01-06-88
		EP-A,B 0078705	11-05-83
		GB-A,B 2108506	18-05-83
		JP-A- 58126862	28-07-83
		US-A- 4554105	19-11-85
EP-A- 0377743	18-07-90	WO-A- 9000560	25-01-90
EP-A- 0296800	28-12-88	JP-A- 2000162	05-01-90
		US-A- 4897387	30-01-90
		US-A- 4973721	27-11-90
WO-A- 8910353	02-11-89	US-A- 4927815	22-05-90
		AU-A- 3573089	24-11-89
		EP-A- 0375757	04-07-90
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		GB-A- 2217715	01-11-89
		JP-T- 2504154	29-11-90
		NL-A- 8920414	02-04-90
EP-A- 0230600	05-08-87	AU-B- 590644	09-11-89
		AU-A- 6601086	23-07-87
		JP-A- 62169762	25-07-87
		US-A- 4758382	19-07-88

FORM P0479

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. [X] OBSERVATION WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This International search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claim numbers 9-14 because they relate to subject matter not required to be searched by this Authority, namely:
see PCT Rule 39.1(iv)

2. [ ] Claim numbers because they relate to parts of the International application that do not comply with the prescribed requirements to such an extent that no meaningful International search can be carried out, specifically:

3. [ ] Claim numbers because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. [ ] OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International search report covers all searchable claims of the International application

2. [ ] As only some of the required additional search fees were timely paid by the applicant, this International search report covers only those claims of the International application for which fees were paid, specifically claims:

3. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. [ ] As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

[ ] The additional search fees were accompanied by applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	EP, A, 0230600 (TEVA PHARMACEUTICAL INDUSTRIES LTD) 5 August 1987 see page 4, compound IV --	1
A	Proc. Workshop on Vitamin D., 1988 , Walter de Gruyter & Co., N. Ikekawa: "Chemical synthesis of vitamin D analogs with selective biological activities", pages 25-33 see page 30, compound 20 --	1,6
A	Bioorganic Chemistry, volume 17, no. 3, 1989, Academic Press, Inc., Tadashi Eguchi et al.: "Synthesis and biological activities of 22-hydroxy and 22-methoxy derivatives of 1 ,25-dihydroxyvitamin D_3: Importance of side chain conformation for biological activities", pages 294-307 see the whole document --	1,6
P,X	Chemical Abstracts, volume 114, no. 17, 1991, (Columbus, Ohio, US), see page 820, abstract no. 164627h & JP, A, 02215766 (HOKUSAN LTD), 28 August 1990 ----------	1,2

INTERNATIONAL SEARCH REPORT

International Application No PCT/DK 91/00091

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5]: C 07 C 401/00, A 61 K 31/59

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[5]	C 07 C 401/00, A 61 K 31/00

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	EP, A, 0078704 (RESEARCH INSTITUTE FOR MEDICINE AND CHEMISTRY) 11 May 1983 see the whole document, especially claim 4 --	1,2
X	EP, A, 0377743 (KURARAY CO. LTD) 18 July 1990 see claim 5 & WO, A, 9000560, 25 January 1990 --	1,2
A	EP, A, 0296800 (YAMANOUCHI PHARMACEUTICAL CO. LTD.) 28 December 1988 see the whole document --	1,6
A	WO, A, 8910353 (WISCONSIN ALUMNI RESEARCH FOUNDATION) 2 November 1989 see claim 1 --	1

./.

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
3rd July 1991	11. 09. 91
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	Falk Heck